Simulation of grinding processes

Numerical tools designed to the comprehension of the grinding process

Introduction

Grinding is a machining process which has the influence of a large number of independent variables. This fact leads to the evaluation of grinding operations based mainly on practical tests, where specific sets of tool and workpiece are studied.

Motivation

Numerical methods are powerful tools on the analysis of such complex environment with interdependent variables. These methods enable the isolation of some influences which can not be analyzed separately in practical experiments.

Grinding process model

The model is based on the description of the geometries and the kinematics involved on the process. The material removal process is assumed as being resultant of the geometric interaction between the tool and the workpiece (as main model simplification, plastic and elastic deformations are neglected).

Special attention is given to the description of the tool geometry, which is divided into macro and micro geometries. The macro geometry (diameter and width, for example) can be easily described with deterministic variables. Nevertheless, the micro-geometry of the tool (the abrasive layer profile or the tolerances of the tool body manufacturing), requires the adoption of statistically described variables. The adoption of these variables with such characteristics requires the application of statistical methods also on the results evaluation.

The description of variables such as grain size and grain morphology is based on detailed measurement of real samples. The results obtained with this evaluation are essential for the creation of representative tool models.

Application of the model

The model has been applied to evaluate the influence of the grain pattern on the performance of Engineered Grinding Tools (EGT). This tool technology is characterized by a mathematically defined arrangement of the grains on the tool body.

The typical challenge on the design of the grain pattern is to reach the balance between the grain pattern parameters (affecting the grain density and the volume available for chips and coolant), the grinding parameters (as the specific material removal rate) and the results expected on the process (as the workpiece roughness and the grinding forces). The wear of the grains edges has a special relevance on the results obtained on grinding processes. On the model, the wear criterion of the grains is assumed proportional to a critical cutting load which the grains are exposed: once the load is exceeded its limits the grain geometry is modified. With consideration of a wear criterion it is possible to investigate, for example, the influence of different grains wear behaviours on the general performance of the tool.

Figure 1 shows the data flow in the simulation of the grinding tool, with consideration of the wear effects on the grains edges. The simulation loop is repeated up to the moment when the tool reaches a stable condition (no grain is overloaded) or one of the tool failure conditions is reached (for example, contact of the tool body with the workpiece).

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August 2008